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An approach of Vector Autoregression Model for inflation analysis in Indonesia

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A B S T R A C T

A control of the inflation rate caused by the fluctuations in foreign exchange reserves, money supply, and exchange rate is required to create the stability of the country's economy. This study aims to analyze the dynamic impact of disturbance factors contained in the variables of foreign exchange reserves, the money supply, and the exchange rate. This research used monthly data from June 2009 to November 2016. It used a method used of Vector Autoregression. The result shows that a foreign exchange reserve has a negative relationship nut not significant effect on inflation, money supply has positive relationship and significant effect on inflation, and exchange rate of rupiah to US dollar has negative relationship and significant effect on inflation. The response of inflation from shocking occurs to supply, foreign exchange reserves and exchange rate tend to be convergent and the biggest contribution that influences inflation the most is exchange rate beside inflation itself.

A B S T R A K

Pengendalian tingkat inflasi yang disebabkan oleh fluktuasi cadangan devisa, jumlah uang beredar, dan nilai tukar diperlukan untuk menciptakan stabilitas ekonomi negara. Penelitian ini bertujuan untuk menganalisis dampak dinamik faktor gangguan yang terdapat pada variabel cadangan devisa, jumlah uang beredar, dan nilai tukar. Penelitian ini menggunakan data bulanan mulai Juni 2009 sampai November 2016. Penelitian ini menggunakan metode yaitu Autoregression Vektor. Hasil penelitian menunjukkan bahwa cadangan devisa memiliki hubungan negatif yang tidak signifikan berpengaruh terhadap inflasi, jumlah uang beredar memiliki hubungan positif dan pengaruh yang signifikan terhadap inflasi, dan nilai tukar rupiah terhadap dolar AS memiliki hubungan negatif dan berpengaruh signifikan terhadap inflasi. Respon inflasi yang mengejutkan terjadi pada supply, cadangan devisa dan nilai tukar cenderung konvergen dan kontribusi terbesar yang paling mempengaruhi inflasi adalah nilai tukar di samping inflasi itu sendiri.

1. INTRODUCTION

Economic development is the way to provide the people with equal prosperity. In that case, a government can be said successful or successful in general when they are able to cope with problems in various fields. And, this is no exception in the economic field. For that reason, every country in the world must have experienced problems in its economy, namely micro issues and macro issues.

Problems in macroeconomic activities can be grouped into short-term problems. Short-term problems are related to the problem of stabilization, which is how to keep in the short term avoid problems such as inflation, balance and balance of payments imbalances. The other is a long-term issue related to the condition of the country can drive in order to have a harmony between economic growth, population growth, increase in production capacity and the availability of funds for investment (Boediono 1980).

Furthermore, one of the macroeconomic indicators to see the stability of a country's economy is indicated by inflation. Changes in this indicator will affect the dynamics of economic growth. In an economic perspective, inflation is a monetary phenomenon within a country; rising or falling infla-

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tion tends to lead to economic turmoil due to price changes. Yet, the phenomenon of inflation is strongly influenced by a number of factors derived from domestic variables and external variables.

This study aims to find out the influence of foreign exchange reserves, the Money Supply (NMS), the exchange rate against inflation, know the inflation response from the shock of foreign exchange reserves, the Money Supply (NMS) and the exchange rate and to know the contribution of foreign exchange reserves, NMS) and exchange rate against inflation.

2. THEORETICAL FRAMEWORK

According Utami (2013), factors affecting inflation are variables variables such as amount of money supply, exchange rate, and government expenditure. The next is about the money supply. It is money in the hands of the people. In this case, money Supply can be defined in the narrow sense (M1) and in a broad sense (M2). M1 includes currency held by the public and demand deposit (demand deposits denominated in Rupiah), while M2 includes M1, quasi money (including savings deposits, rupiah and foreign currency deposits, and demand deposits in foreign currency), and securities issued by the monetary system owned by the domestic private sector with remaining period of up to one year. The money supply in the community must be in an excessive amount. Thus, the amount is proportional to that of the goods produced.

The number of money supply (NMS) affects inflation as described by Fisher's quantity theory. In the theory, Fisher said inflation is closely related to NMS. If there is an increase in the money supply, it will stimulate the occurrence of inflation, assuming the speed of money supply and the volume of economic production is constant. (M.V = P.T). Without an increase in the money supply there will be no inflation, despite price increases.

According Utami (2013), the more open world economy that is characterized by the era of globalization of trade will increase the possibility of external factors (external) potentially raising inflation. Such external powers are usually beyond the control of each country. So that movements in exchange rates can affect the inflation movement in each country in the world as well as in Indonesia because the economic system is an open economy system, which means that, the country wants an international trade transaction.

International trade in the form of exports and imports may affect exchange rate fluctuations. The exchange rate or foreign currency is the price of the foreign currency in the domestic currency unit. In Indonesia, the exchange rate system used is a free-floating exchange rate system, which means that currency price fluctuations will be determined by the supply and demand strength of the currency. Depreciation and appreciation of the rupiah is determined by exports and imports, rupiah depreciation tends to increase exports and reduce imports while rupiah appreciation tends to decrease imports and increase exports. In addition, international trade will bring in foreign exchange reserves or foreign exchange that is indispensable in a country's economy.

Foreign exchange reserves play an important role in demonstrating the strength of a country's economy, as well as avoiding a country's crises in economy and finance (Priadi and Sekar 2008).

Foreign exchange reserves, money supply and exchange rate are macro variables that can affect the economic stability of a country. Economic stability in a country can be seen from the level of economic growth and inflation stability seen from the price of goods in general. Economic stability can be achieved by government intervention, one of which is keeping inflation at a low level to maintain price stability and macroeconomic growth.

3. RESEARCH METHOD

Types and Source of the Data

This study used monthly data from the period of June 2009 to November 2016. Thus, they were time series data in the forms of foreign exchange reserves, the money supply, the exchange rate and inflation taken from the official web of Bank Indonesia.

Data Analysis Technique

The analysis technique used in this study includes such as unit root test, Vector Autoregression (VAR), Impulse Response Function (IRF) and Forecast Error Variants Decomposition (FEVD).

Vector Autoregressive (VAR) Data analysis techniques used in this research are root unit test, Vector Autoregression (VAR), Impulse Response Function (IRF) and Forecast Error Variance Decomposition (FEVD).

Vector Autoregressive (VAR) was first proposed by Sims (1980). It is commonly used to analyze a system relationship for time-series variables and to analyze the dynamic impact of disturbance factors in the system of variables. This approach is a modification or combination of multivariate regression with time series analysis.

Each variable, beside explained by its value in

the past mass, they are also influenced by the past value of all other endogenous variables in the model observed. In addition, in VAR analysis there is usually no exogenous (independent) variable in the model.

Stationary Test

Stationary test is the first step in testing the time series data and this is done on all variables to determine whether they are stationary or not. The stationary test is done by using unit-root test. In this study, stationary test was done using unit-root test with the Augmented Dickey Fuller Test (ADF Test) method on the grounds. In this case, the ADF Test has considered the possibility of autocorrelation in error term if the series used non stationary

Optimal Lag Test

The optimal lag test is used to determine the optimal lag length as being in subsequent analysis and it determines the parameter estimate for the VAR model. It was done due to the estimation of the causality relationship and VAR model which is very sensitive to the length of the lag. Thus, it is necessary to see the data and then determine the accuracy of the length of the lag (Widarjono 2007). Optimal lag determination is done by looking at the value of Schwarz Information Criteria (SIC). The optimal lag is shown by the smallest SIC value.

Vector Autoregression (VAR) Test

VAR model is one of the dynamic linear model (MLD) which is widely used for the application of forecasting of economic variables in long term and in long medium term. In addition, VAR model can also be used to determine the cause and effect relationship. As part of econometrics, the VAR model is one of multivariate time-series discussions.

Basically, VAR analysis can be done with a simultaneous equation model because in this analysis, the study considered several endogenous variables (dependent or bound) together in a model. Each variable, besides being explained by its value in the past mass, they are also influenced by the past value of all other endogenous variables in the model that is observed. In addition, in VAR analysis, there is usually no exogenous (independent) variable in the model.

The standard form of VAR system is as the following:

$$X_t = \alpha + \beta_1 X1_{t-1} + \beta_2 X2_{t-1} + \beta_3 X3_{t-1} + e_T \ . \quad (1)$$

Where:

Xt = Vector element from inflation

X1 = Reserves

X2 = Exchange arte

X3 = NMS

α = Constant vector n x 1

β_n = coefficient from X_t

n = Lag length.

Stability test of Vector Autoregression (VAR)

Stability test is used to see whether the model being used is stable or not. The estimation must have high validity so that their results can be valid. The results can be valid when the model used has stability. If the VAR model used is unstable, the estimation result using the VAR model does not have a high degree of validity. Therefore, the model can be said to have high validity if its root inverse characteristic has a modulus less than one or all within the circle. If the modulus is less than one or is in a circle, then the model is quite stable.

Impulse Response Function (IRF) Test

Impulse Response Function (IRF) analysis was done to determine the impact of fundamental factor shock on inflation. IRF test was done to see the tracks of the effects of one of the shocks on other shocks in the present and future of endogenous variables. A shock in the i-endogenic variable can directly affect the variable itself and will spread to other endogenous variables through the dynamic VAR structure. In addition, IRF provides direction of the relationship of magnitude influence between endogenous variables. Thus, the shock of a variable in the presence of new information will affect the variable itself and other variables in the VAR system.

An IRF analysis is performed to assess the dynamic response of inflation variables, foreign exchange reserves, NMS and exchange rates. All are against the shocks of certain variables. IRF also aims to isolate a shock to be more specific meaning a variable that can be affected by certain shocks. If a variable cannot be affected by shock, then the specific shock can not be known but shock in general.

Forecast Error Variants Decomposition (FEVD) Test

Forecast error variance decomposition is a device in the VAR or VECM model that will separate variations from a number of variables. They are estimated to be shock components or to innovation variables, assuming that the innovation variables are not correlated. Then, the decomposition variance will provide information on the proportion of movement of the shock effect on a variable to the shock of another variable in the current and future periods.

Table 1
Results of Stationary Test at the Level Degree

Variable	Statistic ADF	Mc Kinnon Value (5%)	Prob.
Inflation	-7.0062	-2.8951	0.000
Foreign Reserves	-7.4285	-2.8947	0.000
Exch. Rate	-10.009	-2.8947	0.000
NMS	-9.2896	-2.8951	0.000

Table 2
Results of Optimal Lag Test

Lag	SIC
0	-1.108.763
1	-11.92502*
2	-1.141.341
3	-1.091.354
4	-1.034.560
5	-1.009.245
6	-9.409.327
7	-8.775.410
8	-8.244.730

Forecast error variance decomposition describes the proportion of movement to shock (shock) of a variable to another variable. This method can also see how changes in a variable represented by the change in variance error are influenced by other variables. This method characterizes a dynamic structure in the VAR model. Where in this method can be seen the strengths and weaknesses of each variable in influencing other variables in a long period.

With FEVD analysis, it can be seen how percent of variation in an endogenous variable is explained by any disturbance present in the applied VAR model. In other words, FEVD analysis is used to find out which variable is the most important in explaining the change of a variable.

4. DATA ANALYSIS AND DISCUSSION

The estimate of the VARs requires data to be stationary. Based on stationary test results at the level, the results are as follows.

Stationary Test

Based on the unit-root test on Level (see Table 1), it shows that the absolute ADF statistic obtained for all variable variables is greater than the critical value of Mc Kinnon. It is at a critical value of 5% and has a probability value which is less than 0.05 i.e. 0.0000 on all of its variables. Thus, it can be explained that all variables estimated in this study have been stationary at the same degree at the level. Since the data is stationary at the degree level, the estimate is expected to produce a valid output.

Optimal Lag Test

It is important to determine the optimal lag length in VAR modeling. When the lag is too short, it is probably unable to explain the overall dynamics of the model. If the length of the lag is too long, it will produce an inefficient estimate because of the reduced degree of freedom (especially with small samples.

Based on the optimal lag test, it has the results as shown in Table 2. It is done to produce optimal lag length based on SC criteria that is on lag 1 (first).

Vector Auto Regression (VAR) Test

The result of the estimation shows that inflation can also be explained by inflation, NMS, and exchange rate (see Table 3). However, foreign exchange reserve cannot significantly explain the inflation. The negative sign on the coefficient of foreign exchange reserves indicates that the decline in foreign exchange reserve can increase inflation. In addition, the NMS coefficient has a positive sign, which means that an increase in NMS can also increase inflation. Based on the classical theory, it is stated Irving Fisher that the increase of money supply will not increase the national income but only increase the price level equal to the increase of money supply (Mankiw 2006).

The exchange rate has a negative coefficient, using the Purchasing Power Parity (PPP) theory that states that the exchange rate will change to maintain its purchasing power. Thus it can be said that the foreign exchange rate reflects the compari-

Table 3
Results of Vector Auto Regression (VAR) test

	Inflation	Foreign Reserves	NMS	Exchange Rate
Inflation (-1)	0.935974	0.002202	-0.000249	0.003145
	[21.8075]*	[1.12694]*	[-0.26688]	[1.93559]*
Foreign Reserves (-1)	-8.48127	0.966204	0.015395	-0.043413
	[-1.46952]	[36.7747]*	[1.22469]	[-1.9868]*
NMS (-1)	2.556043	-0.092935	0.995453	0.146779
	[2.22034]*	[-1.77336]*	[39.7007]*	[3.36778]*
Exchange Rate (-1)	-3.787785	0.113688	-0.0119	0.787577
	[-2.3991]*	[1.58183]	[-0.34605]	[13.1764]*
C	24.54168	0.082119	-0.018842	1.270212
	[2.43181]	[0.17875]	[-0.08572]	[3.32452]
R-squared	0.858834	0.973325	0.9977533	0.982466

Details: [ ] = t-statistics *) = significant at α=5%

Table 4
Results of Stability test of VAR

Root	Modulus
0.994074	0.994074
0.949859	0.949859
0.875989 – 0.116162i	0.883657
0.875989 + 0.116162i	0.883657

son between the values of the currency of one country to another which is determined by the purchasing power of each country. Changes start from a certain point of balance, then there is a change in the price level that determines the changes in foreign exchange rates. Changes in foreign exchange rates. If the domestic inflation rate is higher than the inflation of foreign countries, then the value of domestic currency will depreciate and vice versa.

Test of Vector Auto Regression (VAR) Stability

Before testing the Impulse Response Function (IRF) and Forecast Error Variance Decomposition (FEVD) is done, stability test should be done. Stability test needs to be done because it is a requirement for meeting a dynamic model such as VAR. This is due to the requirement that when the study gets unstable VAR model, IRF and FEVD analysis will be said to be invalid. To test whether VAR estimation is stable and has been established, VAR Stability Condition Check should be done in the form of Roots of Characteristic Polynomial. Here are the results of model stability testing:

No root lies outside the unit circle and VAR satisfies the stability condition.

Based on Table 4, it can be seen that the root values of all characteristics or modulus show less than 1. It can also be seen Figure 1, the Inverse Roots of AR Characteristic Polynomial are all inside the circle. Therefore, Table 4 and Figure 1 provide indication that the VAR model is stable.

Looking at the three variables above, the researcher finds that the impact of the response received by inflation is due to the shock of foreign exchange reserves, NMS and the rate during the thirty months that is convergent. Thus, the shock of foreign exchange reserves, NMS and exchange rate will be responded by inflation but not permanent. Inflation will experience self-correcting after reversing the direction sign (Zuhroh and Kaluge 2007).

From the results of FEVD test, it can be seen that variation of inflation is determined by the inflation itself. The contribution to inflation change (Table 5) is 94.41 percent in the first period and declined to 70.43 percent at the end of the study period. The variable with significant contribution is the exchange rate, which is 0.93 percent in the first period and continues to increase until the last period of 22.86 percent. Another variable contributing to inflationary change is foreign exchange reserves with a contribution of 6.08 percent in the second period, the highest contribution of foreign exchange reserves occurring in the seventh period of 6.81 percent and fluctuating until the end of the period in the range of 6 percent to be precisely 6.34 percent.

For the NMS variable, it is not too big in the second period that is 0.001 percent, and it continues to increase until the end period of 0.355 percent.

Table 5
Test Results of Forecast Error Variance Decomposition (FEVD)

Period	S.E.	Inflation	Foreign Reserves	Money Supply	Exchange Rates
1	0.652430	94.41144	5.588559	0.000000	0.000000
2	0.900133	92.98311	6.082020	0.001016	0.933850
3	1.075115	90.88830	6.430809	0.003102	2.677789
4	1.209391	88.47401	6.655519	0.005997	4.864470
5	1.315426	85.97976	6.779786	0.009500	7.230951
6	1.399858	83.56243	6.826601	0.013458	9.597508
7	1.466977	81.31901	6.816641	0.017758	11.84660
8	1.519950	79.30426	6.767700	0.022310	13.90573
9	1.561315	77.54362	6.694609	0.027047	15.73472
10	1.593197	76.04219	6.609380	0.031914	17.31652
20	1.677861	70.85691	6.183725	0.080074	22.87929
30	1.680537	70.65026	6.300848	0.121924	22.92697
40	1.681257	70.59766	6.315707	0.164164	22.92247
50	1.681748	70.56872	6.314113	0.207598	22.90957
60	1.682181	70.53421	6.318303	0.249522	22.89796
70	1.682600	70.49926	6.325701	0.288415	22.88663
80	1.683015	70.46535	6.335137	0.323859	22.87566
90	1.683415	70.43337	6.345529	0.355851	22.86525

Foreign Exchange Rate towards Inflation

The results from the VAR test shows that foreign exchange reserves has a negative coefficient value so that it has no significant effect on inflation. Foreign exchange reserves is one of the sources of state revenues in the form of foreign exchange. Based on IRF test, as in Figure 2, inflation has a negative response at the beginning of period that is equal to -0.15 percent which then decreases in the period to 3 to -0.16, reversed the slop direction in the period to 5 to -0.14 percent and continues to increase until its peak in the 22nd period by 0.02 percent which also became the highest positive response during the study period. From the period 37 to the end of the period did not show any response.

The above condition is reinforced by FEVD test results, in which the degree of the contribution of changes in foreign exchange reserves to inflation is only around ± 6 percent. This can be stated that the foreign exchange reserve has no significant contribution because the floating exchange rate system is free of monetary authority that is not necessary to intervene the market. Thus, there is no need for large foreign exchange reserves.

This study is supported by Utami (2013) that also found that foreign exchange reserves have no significant effect on inflation in Indonesia in the period 2007-2013. This means that the size of the foreign exchange reserves does not affect inflation. This can happen because the accumulation of foreign exchange reserves does not exceed the level of economic growth. The results of this study are supported by Lin, M. Y., and Wang, J. S. (2008) which show that foreign exchange reserves have no significant effect on Inflation in Hong Kong and Singapore. The conclusion of the study is that inflation will increase because the exchange rate effect is stronger than the effects of monetary shock. The inflation rate will decrease if the strong monetary shock effect if placed on the stability of billion is not large. Foreign exchange reserves cannot only stimulate the economy but also to stabilize the most vulnerable variables such as exchange rate, debt and deficit (Commer 2011). According to Kruškovic, BD and Maricic T (2015) the accumulation of foreign exchange reserves does not affect inflation if foreign exchange reserves do not exceed the rate of economic growth.

Amount of Money Supply and Inflation

The current inflation has a positive relationship with NMS in the previous month based on coefficient value of 2.556043. It also has a significant influence on inflation.

Based on the IRF test, inflation shows a very small response from the initial period to the end that is -0.01 percent. This is corroborated by the FEVD test with the degree of NMS change contribution to inflation. It can be seen that NMS does not contribute to inflation change because the contribution of NMS to inflation is very small that is only 0.001 percent in the second period and increased slightly to 0.355 percent in the final period.

As viewed from the demand side, increasing

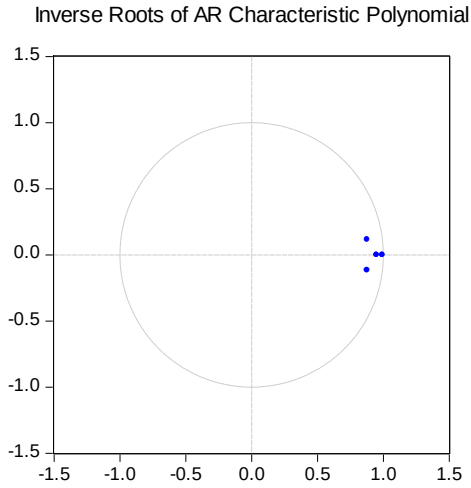

Figure 1
Results of Stability Test VAR

money supply encourages people to increase their demand. From the supply side, the increase in the money supply will decrease the real income of the community, so the people, especially producers, will raise the price of the products to maintain their real income. This can lead to higher production costs through high production inputs, both inputs and labor inputs demanding wage increases so manufacturers tend to reduce their production activities. With the above process, although the quantity of commodity slightly increased, but the price has increased. According Langi, et al. (2004) NMS percentage change in the short term has a negative and insignificant relationship to percentage change Inflation rate in Indonesia. While in the long term NMS has a positive and significant relationship to the inflation rate in Indonesia. Utami and Daryono (2013) stated that the NMS has a significant effect on inflation in 2007-2013 and also in Putra and Meydianawati (2015) stated that NMS influenced inflation significantly and positively in the first lag.

Exchange Rate and Inflation

Based on the VAR test, inflation currently has significantly a negative relationship with the exchange rate in the previous month.

Based on the IRF test inflation, it has a negative response since the second period with a value of 0.09 percent and continued to experience a negative response to the period to 7 with a value of -0.26 percent which then reversed course in the period to-9 is -0.25 and continues to rise to its peak in the 30th period of 0.01 percent, but in the period 31 to the end of the inflation period did not show response to changes in exchange rates. While the magnitude of the exchange rate contribution to inflation is explained in the FEVD test, it can be stated that the exchange rate has a considerable contribution of 0.93 percent in the first period and continues to increase until the last period of 22.86 percent.

By using Purchasing Power Parity (PPP) theory, which states that, the exchange rate will change to maintain its purchasing power. Thus, it can be said that the foreign exchange rate reflects the comparison between the values of the currency of one country to another which is determined by the purchasing power of each country. Changes start from a certain point of balance, then there is a change in the price level that determines the changes in foreign exchange rates. Changes in foreign exchange rates. If the domestic inflation rate is higher than the inflation of foreign countries, then the value of domestic currency will depreciate and vice versa. (Nopirin 2011). Based on the results of VAR tests that have been done, the exchange rate has a negative and significant effect on inflation in Indonesia. In line with the PPP theory, it is assumed that the rise of domestic inflation is higher than the rise of foreign inflation, the exchange rate will depreciate. The results of this study are in line with research conducted by Endri (2008) which states that exchange rates have a significant effect on inflation and based on IRF test and FEVD test shows a significant contribution in influencing inflation in Indonesia.

5. CONCLUSION, IMPLICATION, SUGGESTION, AND LIMITATIONS

This study investigates the effect of Money Supply (NMS), Foreign Exchange Reserves and Exchange Rate on Inflation in Indonesia. It can be concluded that the relationship between inflation and foreign exchange reserves is negatively insignificant. Inflation has a significant and positive relationship with NMS but a significant and negative relationship with the exchange rate, which is in accordance with the initial hypothesis.

IRF test results show that the response received by inflation is due to the shock of foreign exchange reserves, NMS and exchange rate during the thirty months and it is convergent. Thus, the shock of foreign exchange reserves, NMS and exchange rate is responded by inflation but not permanent. Inflation will experience self-correcting after reversing the direction sign. In addition, as based on the FEVD test result, the biggest contribution affecting inflation is the exchange rate apart from inflation itself. Implicitly, the exchange rate is important factor beside inflation.

This study suggests that the researchers for further research should do the research on inflation by using the VAR method. They can continue by

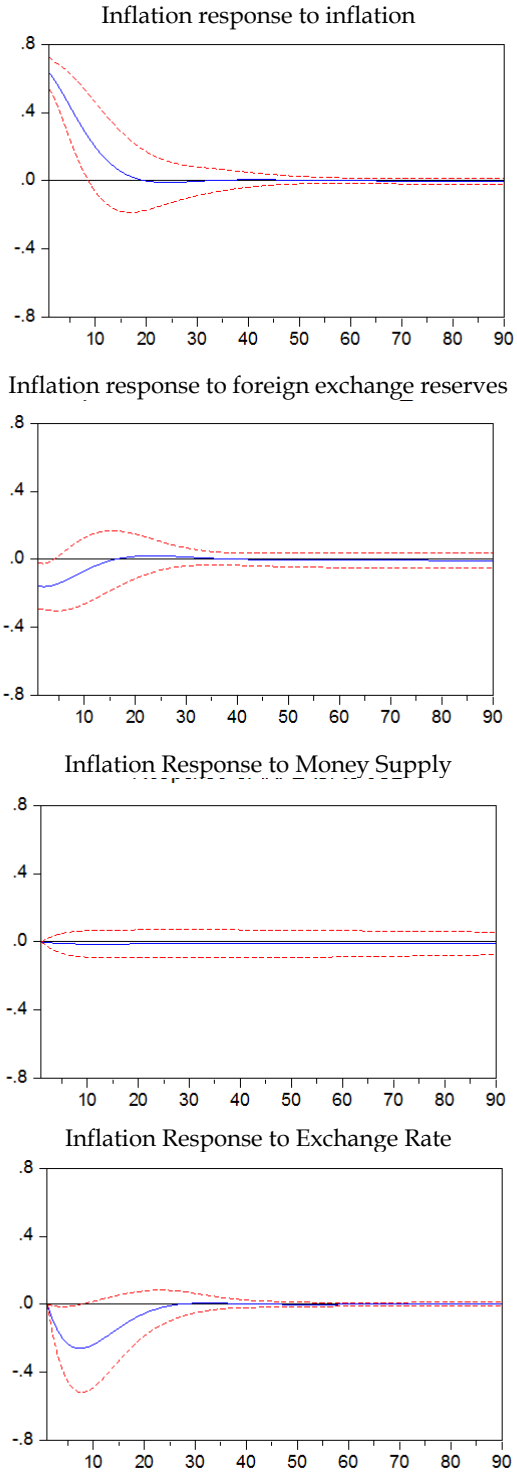

Figure 2
Results of IRF Test

developing other macro variables such as interest rates and Gross Domestic Product (GDP). This is intended for them to enrich the literatures. When viewed from the test results VAR, there has not been a series of diagnostic tests such as normality, autocorrelation and heterocedasticity so that the results is obtained stronger. The implications of government policy that can be done based on the results of this study is the control of the Money Supply must be done one of them by raising the deposit rate, so that the public will increase the saving that will suppress the circulation of money so that inflation can be controlled.

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